

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



April 9, 2018

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-072

A. ACCIDENT INFORMATION

Place : Gila Bend, Arizona
Date : October 5, 2016
Vehicle : Bell UH-1H, N175SF
NTSB No. : WPR17LA002
Investigator : Elliott Simpson, AS-WPR

B. COMPONENTS EXAMINED

90-degree Tail Rotor Gearbox and Top of Vertical Fin

C. DETAILS OF THE EXAMINATION

The as-received gearbox and tail rotor components and top of the vertical fin are displayed in figure 1. The input quill was separated from the gearbox at the assembly joint. As viewed in the upper view of figure 1, the input quill would rotate clockwise. The six studs that attach the input quill to the gearbox housing and the vertical fin were fractured at the input quill to gearbox housing joint line. The lower portions of 5 of the 6 studs were retained in their respective mounting holes in the fin. The sixth stud was found loose in the box that it was received in.

The illustrated parts breakdown indicated that the standard studs were to be AN126420¹. AN126420 studs are 2.875 inches long. The fine threaded ends of the studs were marked "E11" as required by the standard. The ends of the coarse threads were not available to determine if they were marked as over or under sized.

The upper, coarse threaded, portions of the fractured studs were retained in the gearbox case assembly as shown in center view of figure 2. The studs were arbitrarily numbered #1 through #6 in a clockwise direction with #1 at the forward side of the gearbox. With the studs cleaned, all six fractures displayed surface topographies and arrest lines indicating bending fatigue cracking. In each case, the fatigue initiated at multiple origins in the thread root radii on the clockwise side of each stud. Initiations areas are indicated by yellow bracket on each stud in figure 2. The fatigue cracks propagated diametrically across each stud terminating in small overstress regions outlined in yellow. A small area of secondary reversed bending fatigue cracking was also noted at the opposite side of each stud. The fatigue cracks penetrated between 89% and 98% of each stud cross section.

¹ Air Force-Navy Aeronautical Standard, AN126275 thru AN126586, Stud, Straight, .3125-18 x .3125-24.

The recovered lower portions of the studs containing the fine threaded ends and nuts, are displayed in the upper view of figure 3, after cleaning in acetone with ultrasonic agitation. Studs #1, 2, 3 4 and 6 had been retained in their original locations in the vertical fin by assembly sealant applied to the nuts. When removed, each stud had two washers between the nuts and the fin structure. Stud #5 was found loose in the receiving box with no washers.

Magnified examinations of the studs and fracture areas found that the fatigue cracks had initiated at multiple locations the either the first, second or third full threads from the grip portion of the stud. The thread roots were smooth and typical of rolled thread roots. Yellow paste material consistent with zinc chromate paste was present in all thread roots.

The unthreaded grip sections of all studs were marked by fretting wear on one side and typified by the lower images in figure 3. The fretting was on the grip side opposite the main fatigue crack origin areas. In most cases the wear scars corresponded to the length of the stud that passed through the vertical fin structure and in some instances, was present on the adjacent thread crests. Shorter fretting wear patterns were present on two studs. The fretting was not present on the stud lengths that passed through the input quill support housing.

The corresponding locations on the fin structure were worn and slightly out-of-round, as shown in figure 4. Examining the interior of the fin holes also showed wear and damage corresponding to the fretting on the studs, as shown in figure 5.

AN126420 requires the studs to be made from AMS 6322² and hardened to HRC 26-32. Hardness measurements made on the unthreaded diameters of three random studs and corrected for geometry ranged between HRC 27 and 32. The composition as determined by x-ray fluorescent spectroscopy³ was consistent SAE 8740 as required.

The upper bearing on the input quill shaft was separated and only the cage and races were received. The raceways appeared normal and the damage was consistent with the separation of the studs and subsequent movement of the gearbox. The interior of the gearbox was also locally ground and abraded consistent with continued rotation of the input quill during separation of the gearbox.

Joe Epperson, FASM
Senior Metallurgist

² SAE International, Aerospace Materials Specification 6322, Steel Bars, Forgings, and Rings, 0.50Cr - 0.55Ni - 0.25Mo (0.38 - 0.43C) (SAE 8740)

³ Thermo Scientific Niton XL3t-980 x-ray fluorescence (XRF) alloy analyzer

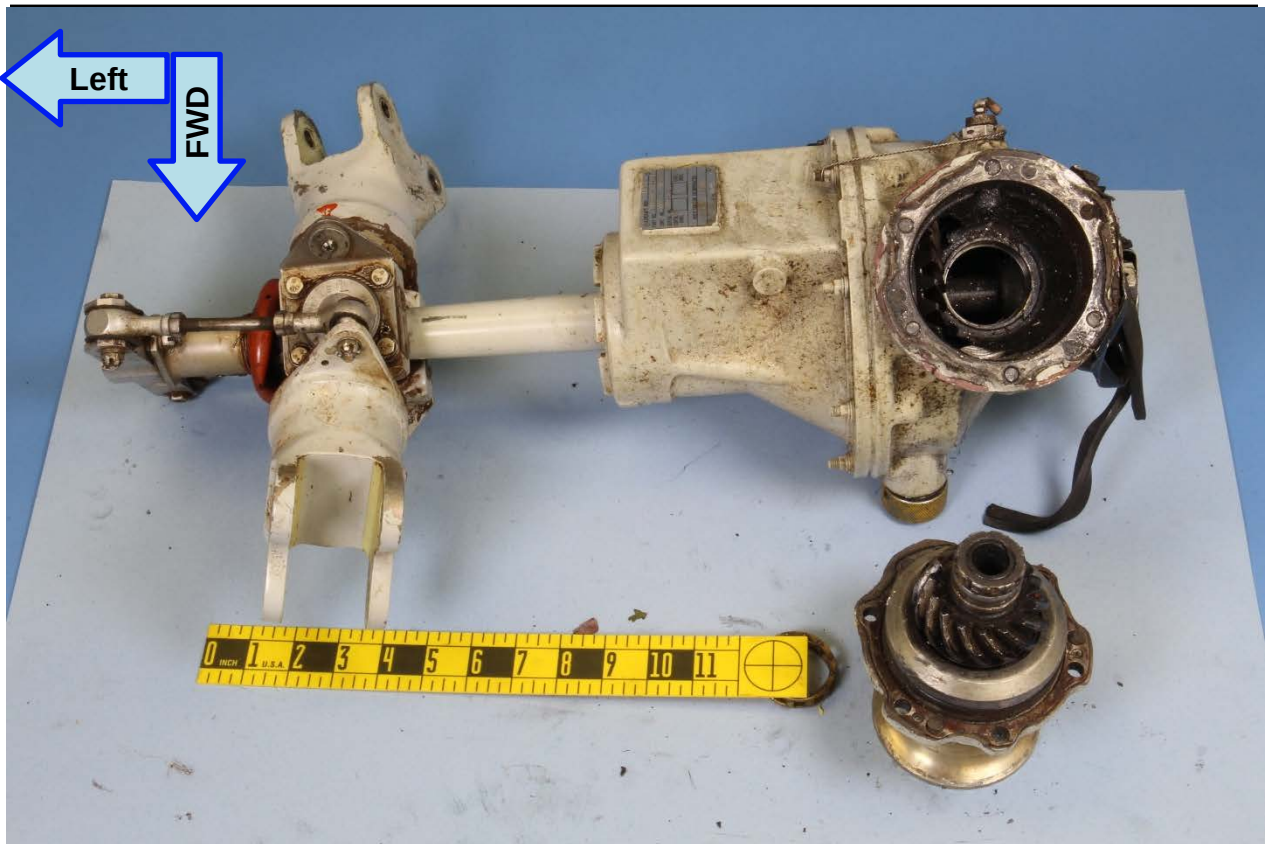


Figure 1. Overall views of the as-received components. Tail rotor gearbox with separated input quill at top and the upper portion of the vertical fin with gearbox mounting studs below.

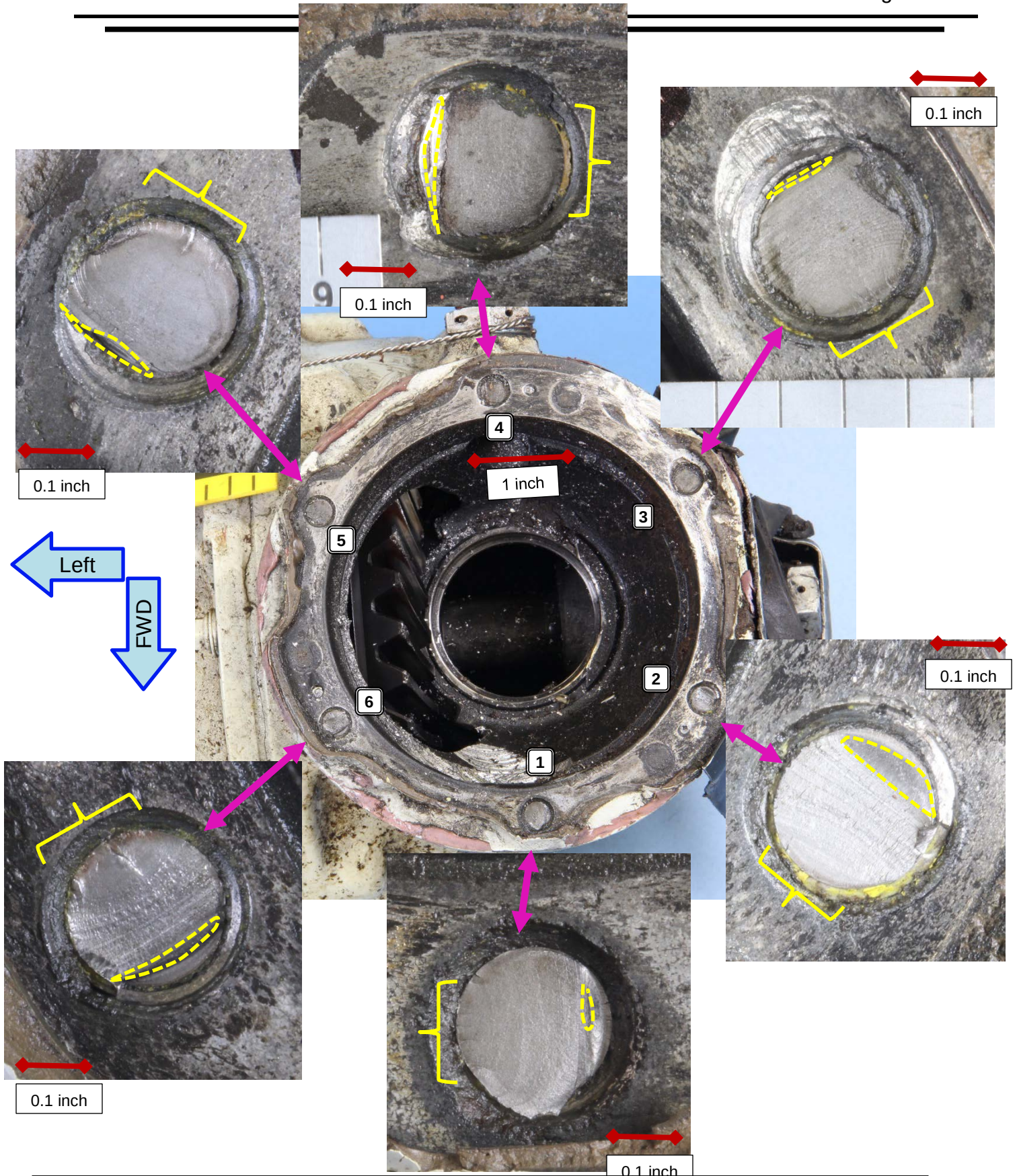


Figure 2. Central image shows the placement of the fractured studs in the gearbox housing. Enlarged images of the stud fracture faces shown surrounding. Brackets indicate main fatigue origin areas and dashed lines outline the final overstress regions on each stud.



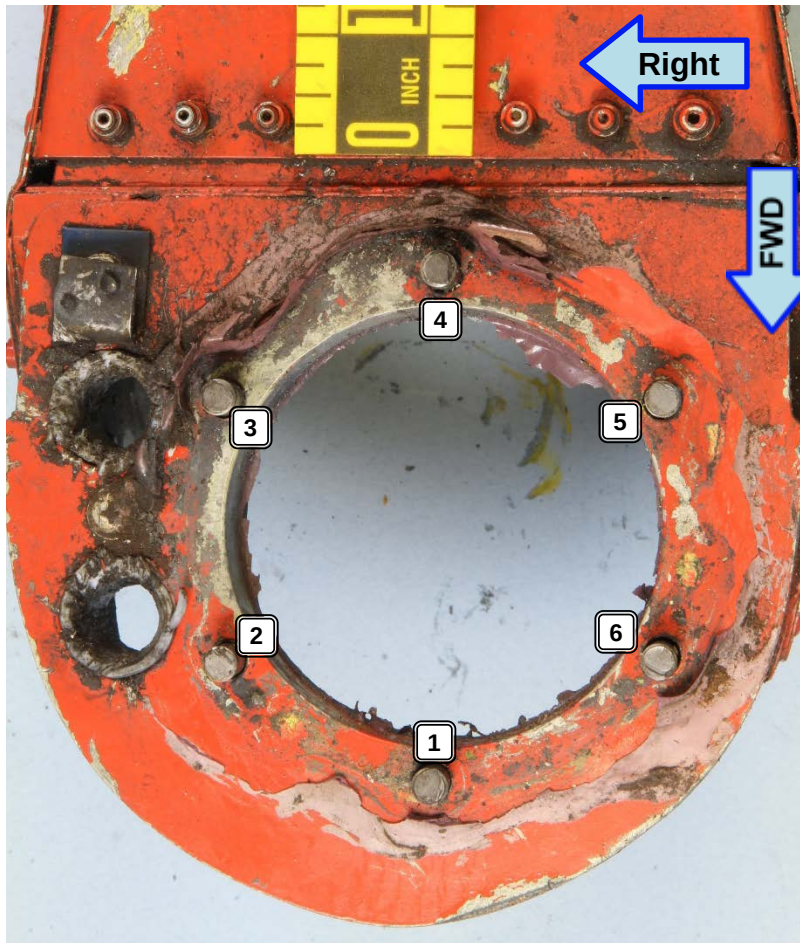


Figure 4. Top down views of the gearbox mounting area on the top of the vertical fin with studs numbered at left. Lower two views show the wear (between yellow arrows) to the #1 stud hole.

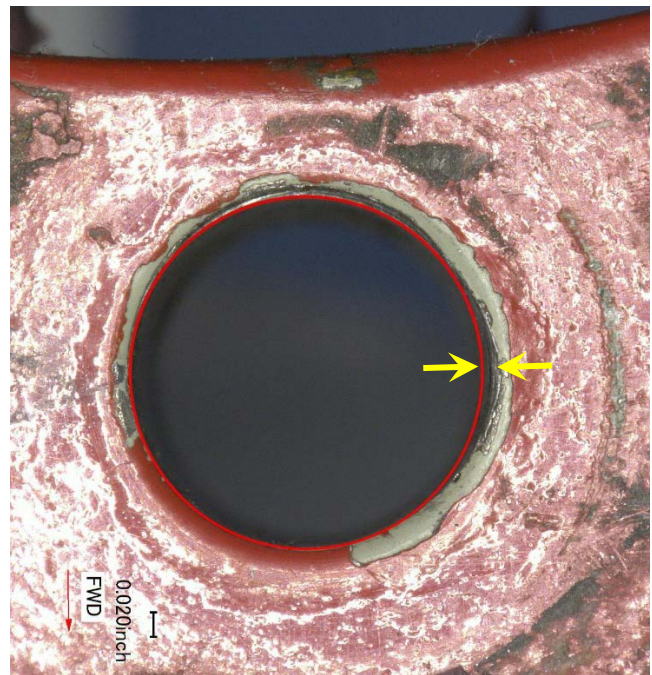
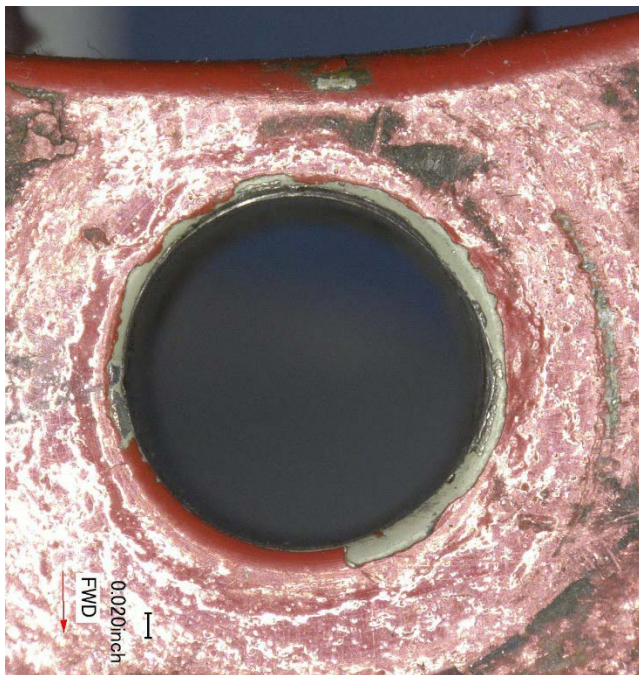




Figure 5. Two views of the #3 stud hole. Left view shows a plan view with the wear between the yellow arrows. Right image shows the wear on the interior of the hole corresponding to the fretting wear on the stud.